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NOMENCLATURE OF THE ALLOYS "BRASS," "BRONZE" AND SO-CALLED "GOVERNMENT BRONZE."

Many inquiries come to the Bureau of Standards in regard to the nomenclature of brasses and bronzes. This letter circular has been prepared to answer such inquiries.

Brasses.

Alloys of copper and zinc containing 50% or more copper and no other alloying metal beside zinc are brasses. The zinc content will normally run from 5 to 50% in the simple brasses. Alloys with over 50% zinc are referred to as "zinc-base alloys."

As long as the copper alloys contain only one metal beside copper, i.e., zinc in brass, and tin in bronze, there is little difficulty in assigning correct names, although there is some confusion of terminology even in these simple alloys.

There is a large production of true, simple, brasses in wrought form, but a third metal, lead, occurs in many industrial brasses, the usual name given to such a ternary alloy being "leaded brass," or "lead brass." When any intentional admixture of lead, however, small, is made this term is usually applied to distinguish the alloys from those that are lead-free, since for some purposes only practically lead-free alloys will serve. Because there is wide use of real brass, the term has held its own, connoting a copper-zinc alloy unless otherwise qualified

There is no great misuse of the term "brass," save that in railroad parlance any bearing, even though it may contain no zinc at all, is often called a "brass," the term referring to the object, i.e., the bearing, rather than to the alloy. Brass of 60% copper, 40% zinc is often termed "Muntz metal." Such names, applied to specific compositions, are less common in the brasses than in the bronzes.

Bronzes.

Alloys of copper and tin, containing 50% or more copper and no other alloying metal, beside tin, are bronzes. Outside of a very few alloys including certain bell metals, speculum metals or metals for special bronze files, the tin content is normally under 20%. Alloys with over 50% tin are referred to as "tin-base" alloys.

The term "bronze" has nowhere near as unmistakable and definite a meaning as the term "brass." There is very little use of simple binary bronzes containing copper and tin alone. To make these alloys better fitted for industrial use, it is customary to add more or less zinc, and almost as often,more or less lead. When the lead content is 10% or over, often up to 30%, these copper-tin alloys, irrespective of the zinc content, which is, however, usually low, are commonly termed "leaded bronzes" or "lead bronze." Such alloys find use practically only as bearings.

The term "zinc-bronze" has been suggested and is in fairly common use to designate a copper-tin alloy to which zinc has been added, but in which the strengthening effect due to both the alloying elements is considered as being chiefly due to the tin. Thus the older alloy 88% copper, 10% tin, 2% zinc, (88-10-2) and its more modern counterpart 88-8-4, with less tin and more zinc, are precisely called "zinc-bronzes," although for brevity the word zinc is often omitted and the term "bronze" used alone. In fact, if one wishes to speak of an alloy of copper and tin alone, he will generally refer to it as a copper-tin alloy or else call it a "tin bronze" to make clear that he is referring to the simple binary alloy and not to any other alloy that has been termed bronze.

If phosphorus or silicon is added to a simple copper tin alloy, either merely as a deoxidizer or in such amount that it acts as an alloying element, the resulting alloy, whether any phosphorus or silicon is or is not detectable by analysis in the alloy after casting, is termed "phosphor-bronze"(or "phosphorus-bronze)",or "silicon bronze."

When the alloys contain but three elements the use of the name of the third added element before the word "bronze" is therefore fairly well established for scientific terminology. But for brass, usage is not so well established. The term "leaded-brass" is in common use, but a brass containing a little tin, which by analogy would be called "tin-brass" is seldom so called. Instead, such terms as"Admiralty metal" or "Tobin bronze," are used, the latter being obviously a misnomer because, while a very little tin enters into the alloy, the zinc is present in far larger amount and is more responsible for the alteration of the properties of the copper with which the two elements are alloyed. If a little nickel is added to "Admiralty metal" the alloy is sometimes termed "Adnic." These specific terms, however, do have the advantage, when they refer to a single definite composition, of connoting to one who is familiar with the term, both the qualitative composition as to alloying elements and the quantitative composition, i.e., the amounts of each present. To a great many, however, these specific or trade terms are confusing. Confusion is worse confounded when a trade name comes into use, not for a single,definite composition, but for a whole family of alloys.

Some specific terms may be very misleading. "German silver," for example, contains no silver and the only excuse for the term was that the alloys are white in color. These copper, nickel, zinc alloys are now more often termed "nickel silver," which is also a misnomer. They are more properly termed "nickel-brasses," The American Society for Testing Materials has a committee which is considering the nomenclature of this and other non-ferrous alloys, but it has not yet made recommendations. According to a decision of the United States Federal Trade Commission (docket 1479, Feb. 6, 1928) the words "nickel silver" should not be used to advertise or describe alloys which do not actually contain both of those metals.

Complications occur even with the use of the family name "nickel-brass," as with "leaded-brass," "zinc bronze," etc. because the name does not connote the exact composition. It is possible to describe a nickel brass containing 20% nickel, 18% zinc, balance copper as "20-18 nickel brass."

But even such a system becomes cumbersome with a four-component alloy. In referring to the very common alloys of copper, tin, zinc and lead it is not concise to call them "zinc-lead bronzes," or "tin-lead-brasses." In many cases it is difficult to decide whether the tin predominates as an alloying element, making the alloy a bronze, or the zinc, making it a brass. One cannot decide on the basis of whether zinc or tin is present in the larger percentage, since a given percentage of tin affects the alloy more than an equal percentage of zinc. In the alloy 85% copper, 5% tin, 5% zinc, 5% lead ("85 and three 5's") a slight change in the tin content will affect the properties more than an equal change in zinc so that it cannot be called a misnomer to term the alloy a bronze. It is about as often called "valve bronze" as it is "red brass," or, evading the question of whether it should be viewed as a bronze or a brass, "composition metal," or "ounce metal," (See A.S.T.M. Spec. B-26-28). (The alloying elements are in approximately the ratio of one ounce each to one pound of copper).

Where definite specifications exist, such as those of the Federal Specifications Board or the American Society for Testing Materials, reference to the specification number definitely fixes the composition, qualitatively and quantitatively. Thus F.S.B. No. 2 bronze for castings is the "85 and three 5's" alloy.

There is little uniformity in terminology even in accepted specifications for, according to A.S.T.M. specification B-30-22, the "85 and three 5's" alloy and one with 8% tin and 3% zinc are termed "brass." On the other hand F.S.B. No. 4 "bronze for castings" contains 77% copper, 3% tin, 10% zinc and 10% lead, and No. 3 contains 13% zinc.

The question whether an ornamental casting, used as a book-end, which contained 85% copper, 2% tin, 12% zinc and 1% lead was to be classed as brass or bronze was discussed by the Better Business Bureau of New York City, and, at a conference held November 14, 1927, that conference agreed that art castings stamped or described as bronze should contain a minimum of 85% copper and 3% tin. Since color, weight and ability to be cast govern the choice of an alloy for such uses, rather than the mechanical properties, it is obvious that to insist on a high percentage of tin in alloys for such uses, is an economic waste. Whether the intrinsic value of the alloy enters the situation so as to make the use of the term "bronze" for a low-tin alloy a case of real misbranding is a problem outside the scope of the present discussion.

The multiplicity of alloys of copper-tin-zinc and lead in commercial use complicates the problem of nomenclature. With a few well-recognized alloys described by specifications, the specification number would come to have a definite meaning such as is connoted by the designations "No. 12 alloy," "No. 17 alloy," for aluminum alloys. Restriction of the number of alloys handled is an advantage in any foundry, providing that the alloys actually cover the engineering needs to which they are applied.

However, the properties of these quarternary alloys in general vary only gradually with reasonable changes in composition. Alloys of compositions between the limits of composition set for two "standard" alloys of the F.S.B. or A.S.T.M. lists may be entirely usable, and in some conditions of the metal market or for some specific conditions of a given plant or in a given application, may be both cheaper and better. A specific machining operation with certain tools on a certain casting may perhaps be more economically done on a "non-standard" alloy and the advantage so gained may entirely justify adding such a special alloy to the list made by a given plant.

Instead of there being for a given purpose but one, hard and fast, fixed composition whose specification limits may not be exceeded without producing inferior material there is, in bearing bronzes at least, a range of compositions of practically equal engineering value. (See Bureau of Standards Research Papers No. 13 and No. 68. The purchaser who lays down needlessly close specifications adds to the cost of manufacture and to the purchase price, without any corresponding gain. Similarly a specification or the desire to limit the number of alloys handled, which tends to require the use of more tin than the engineering requirements of the case demand, operates against the much-needed conservation of tin.

While a simplification of nomenclature is obviously desirable, it is equally obvious that simplification through establishment of specifications whose numbers can be used to designate the particular alloys is a matter not for hasty judgement.

"Government bronze."

There is a widespread but erroneous belief that there is a definite composition of bronze officially accepted by the United States Government as the "best" bronze. One of the alloys of longest commercial use is that of 88% copper, 10% tin, 2% zinc, or "88-10-2". Back in the days when cannon were made of bronze this was known as "gun bronze" and for many years the U. S. Navy had a specification for Navy "G" metal of this composition. A.S.T.M. specification B-10-18 covered this alloy, but is now replaced by B-60-28 for the 88-8-4 alloy.

The separate Navy specifications for this alloy are now superseded by the F.S.B. specifications, and the 88-10-2 alloy does not appear therein, (though it could, of course, be purchased by the government as a non-standard alloy if there were need for it). It is superseded by F.S.B. No. 5, 88-8-4 in which the tin content is lower and the zinc content higher, this composition being on the whole a better all-around alloy for a certain group of purposes than the 88-10-2.

But the 88-8-4 is no more a "government bronze" than any of the others in the F.S.B. specifications.

In the field of statuary bronzes or "art bronzes," there is a similar erroneous idea that there is one "government bronze" the composition of this one being set at 90% copper, 7% tin, 3% zinc. The history of this seems to be that back in 1895, in regard to the Hancock statue, it was specified in a letter by an individual purchasing officer that the "U. S. Standard bronze to be used should consist of 90 parts of copper, 7 parts of tin, 3 parts of New Jersey refined spelter," One or two firms, assuming that this phraseology had legal effect, set up this composition as, in their estimation, "U. S. Standard" and have claimed that the phrase should be used in somewhat the same manner as the terms "Sterling silver" or "Eighteen carat gold" are used. That, even in its statuary purchases the government has not necessarily adhered to this "Standard" is shown by the fact that the bronze group in front of the Library of Congress was made of an alloy of 90% copper, 8% tin, 2% lead.

There is a prevalent idea that a statuary bronze must contain at least 90% copper, so that it will not stain a stone foundation, and that a similar copper content is required to allow the statue to acquire a pleasing patina. The correctness of these ideas seems doubtful. Various alloys exposed for over ten years at the Bureau of Standards show very little difference in color. One containing 80% copper, 3% tin, 16% zinc and 1% lead would apparently be a very satisfactory alloy for the purpose, as would one of 83% copper, 5% tin, 2% zinc and 10% lead.

Vickers (Metals and Their Alloys, 1923, pages 353-358) gives a wide range of compositions for art bronzes. Noted statues vary so in composition that it is clear that there are no fixed "ideal proportions" for art bronze, as well as no "U. S. Government Standard."

Manganese Bronze.

The term "bronze," while primarily connoting a copper-tin alloy, is also used, with some modifying adjective, to refer to strong alloys of copper containing little or no tin. "Manganese bronze" is a name given to a group of alloys containing, besides copper, about 38 to 45 per cent zinc and small amounts of other elements such as tin, iron, aluminum and manganese. One type contains about 3-1/2 per cent manganese while in another the manganese content may be only 1/2% or even less. These alloys are really high-strength brasses. The name is so ingrained in engineering practice that replacement by more precise terminology of the present name, which is really erroneous, would be none too easy.

Aluminum Bronze.

The alloy of about 90% copper with about 10% aluminum (with or without a little iron) is generally called "Aluminum bronze." The alloy contains no tin, nor does it have a bronze color. Outside of trade names, the use of which should be discouraged, no short, descriptive name for the "aluminum bronzes" appears to have been suggested, and, even in F.S.B. specifications the terms "manganese bronze" and "aluminum bronze" are still used for want of better ones.

Many other "bronzes" so-called in trade terminology, are given in Campbell's List of Alloys, (Proc. A.S.T.M. Vol. 22, Pt. I, 1922, p. 213), under the brasses. On the other hand one alloy of 24% tin among the bronzes has been called a "brass," according to Campbell's list.

On account of the fact that the color of the alloy is similar to that of true bronzes - the alloy of 90% copper, 10% zinc, used to a considerable extent for wrought products, is quite generally termed "bronze" or "commercial bronze," "Bronze" wire for screen cloth is often made from this alloy.

Still another use of the word "bronze" is in reference to the metallic pigments used in "bronzing" paints. Finely divided, flaky metal particles, whether of copper, copper-zinc alloy or aluminum, used for this purpose are termed "bronze powders." Hence "aluminum bronze" may refer either to the 90% copper, 10% aluminum alloy or to an aluminum powder pigment, neither material being a bronze.

With such looseness of terminology, and such a wide range of alloys in use, it is obvious that statistics of production of "brass" and "bronze" may not be used with great certainty or exactness for such purposes as attempting to calculate the amount of tin or zinc entering into the products.

References on nomenclature of non-ferrous alloys:-

W. Rosenhain, A note on the nomenclature of alloys, Jour. Inst. of Metals (British), 7, 1912, p. 191.

G. K. Burgess and C. P. Karr, Nomenclature of non-ferrous alloys, Trans. Am. Inst. of Metals, 7, 1913, pp. 141,-147.

W. Campbell, A list of alloys, Proc. Am. Soc. for Testing Materials, 22, Pt. I, 1922, p. 213.

Prohibition extends to "Nickel Silver" - Editorial - Iron Age, 121, 1928, p. 961.

Non-ferrous alloys and their names - correspondence - P. E. McKinney, W. F. Graham, Iron Age, 121, 1928, p. 961.

W. Guertler, Consistent International Nomenclature of Alloys Int. Zeit. für Metallography, 6, 1914, p. 23.

Federal Specifications Board specifications for brasses and bronzes are:-

Bronze castings, Spec. No. 172a.	
" ingots for remelting, 290a	
Brass castings to be brazed, 286.	
Aluminum bronze ingots for remelting,	173a
" " castings	369a
Phosphor-bronze spring wire,	532
Manganese bronze castings	370

Manganese bronze ingots for remelting, 89
" " rods, bars, plates and shapes, 552,
Brass rods, bars, plates, shapes, sheets and strips,
commercial - 392.
Naval and commercial brass castings, 272
Brass pipe - seamless, 342a
" tubing " 427
Condenser tubes 374

American Society for Testing Materials specifications for brass and bronze:-

1927 Standards, Part I, B 10 - 18. The alloy: copper, 88 per cent; tin, 10 per cent; zinc 2 per cent, p. 579.

B 30-22 Brass ingot metal graded and ungraded, for sand castings, p. 582.

B 31-21 Bronze bearing metal in ingot form, p. 586.

B 22-21 Bronze bearing metals for turntables and movable railroad bridges, p. 589.

B 7-27 Manganese-bronze ingots for sand castings, p.593.

B 54-27 Manganese-bronze, sand castings, p. 585.

B 14-18 Seamless brass boiler tubes, p. 618.

B 44-24 Seamless admiralty condenser tubes and ferrule stock, p. 622.

B 55-25 Seamless 70-30 brass condenser tuber and ferrule stock, p. 626.

B 56-25 Seamless Muntz metal condenser tubes and ferrule stock, p. 630.

B 57-27 Muntz metal condenser tube plates, p. 633.

B 43-24 Brass pipe, standard sizes, p. 639

B 15-18 Brass forging rod, p. 643.

B 16-18 Free-cutting brass rod for use in screw machines, p. 646.

B 19-19 Cartridge brass., 650

B 20-19 Cartridge brass disks, p. 654.

B 21-27 Naval brass rods for structural purposes, p. 655.

B 36-27 Sheet high brass, p. 658.

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